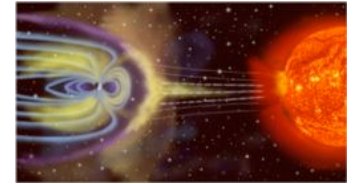


Global aspects of Heliosphere-Geosphere Coupling



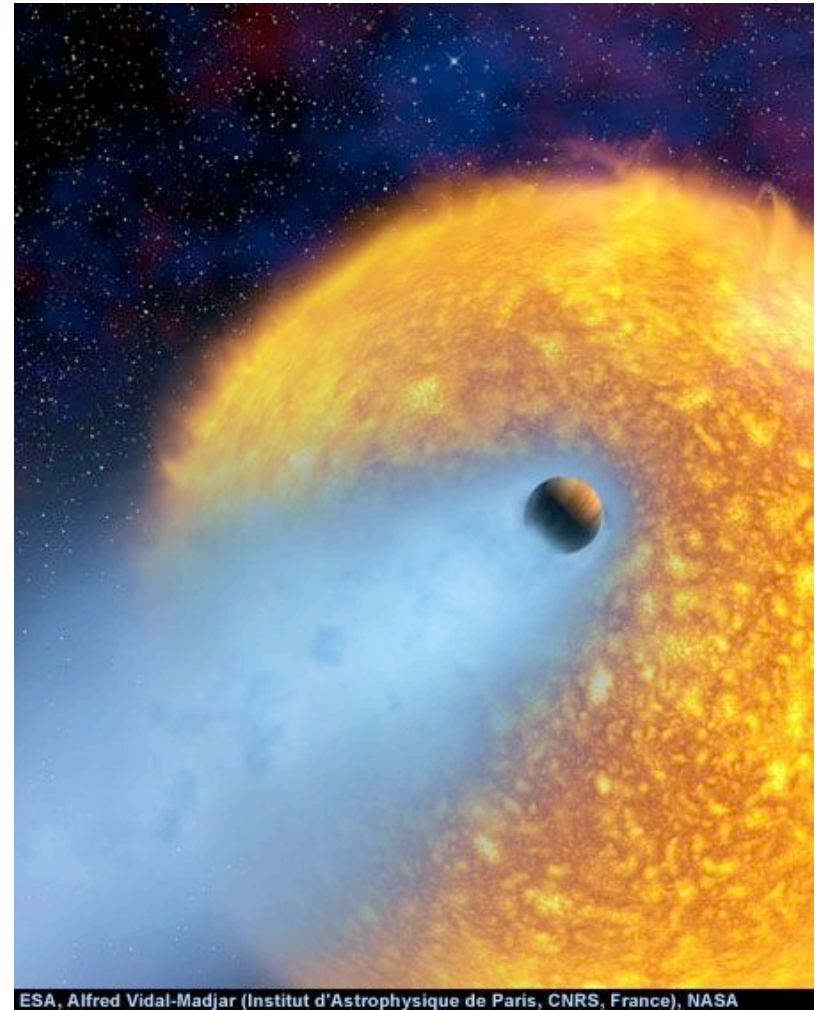
T E Moore¹, M-C Fok¹, D C Delcourt²,
S Slinker³, J Fedder⁴, M Buenfil¹

1. NASA's Goddard Space Flight Center
2. CETP, St.-Maur, France
3. Naval Research Laboratory
4. LET Corp.

Moore, Fok, et al., JGR Feb 2005 "Solar
and Polar Wind..."

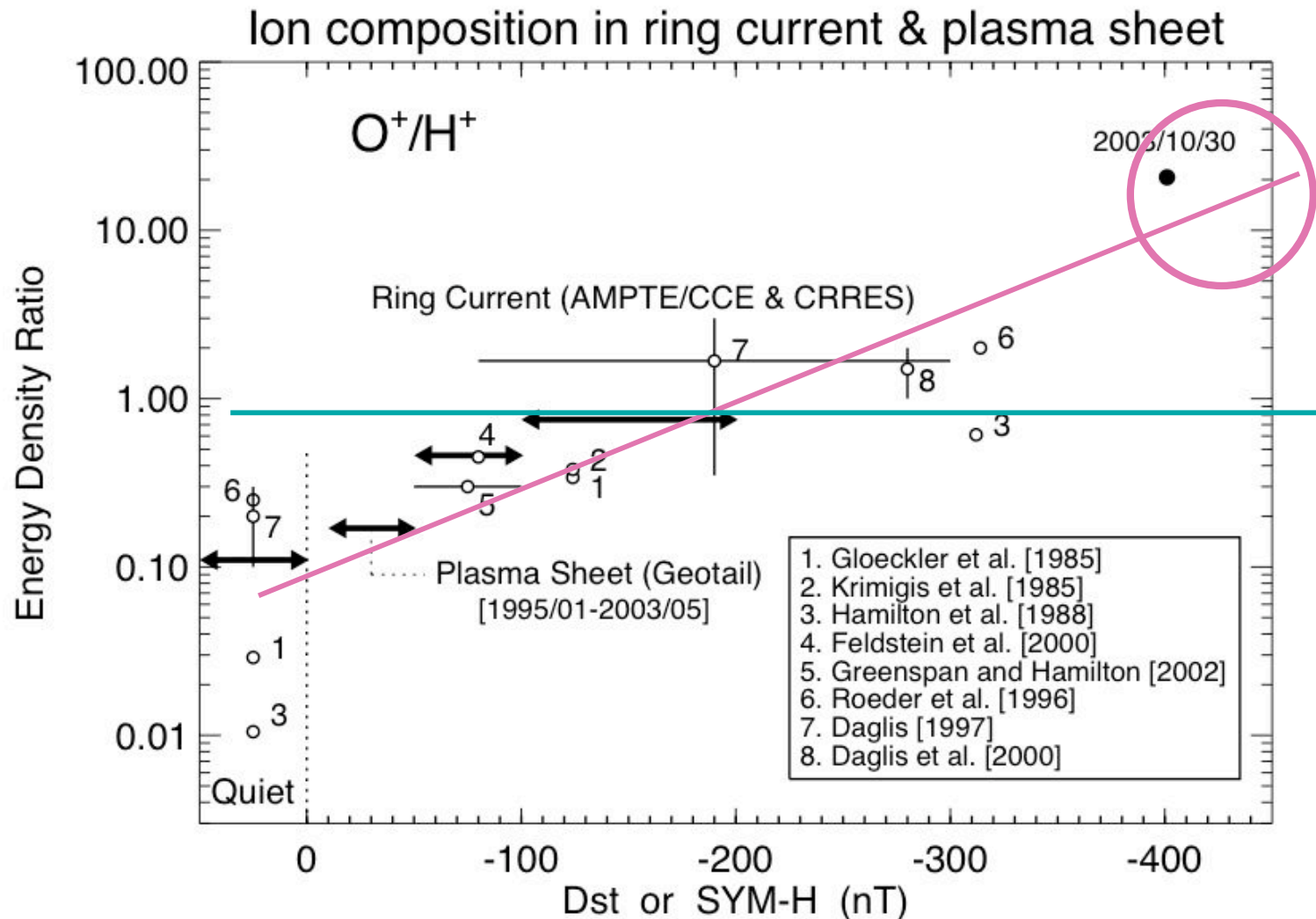
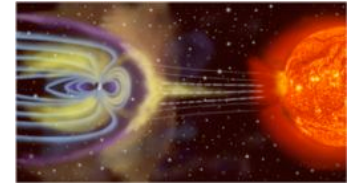
Moore, Fok, et al., Geophys. Mono. 159,
2005, "Ionospheric Plasmas in the Ring
Current"

Nosé, Christon, Taguchi, Moore, Collier,
JGR 2005, "Overwhelming O+..."



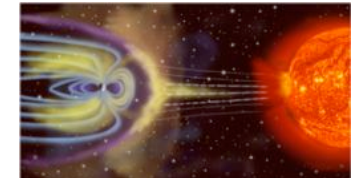
Inferred ablation of Osiris' atmosphere

Halloween 2003 on D_{ST} Trend



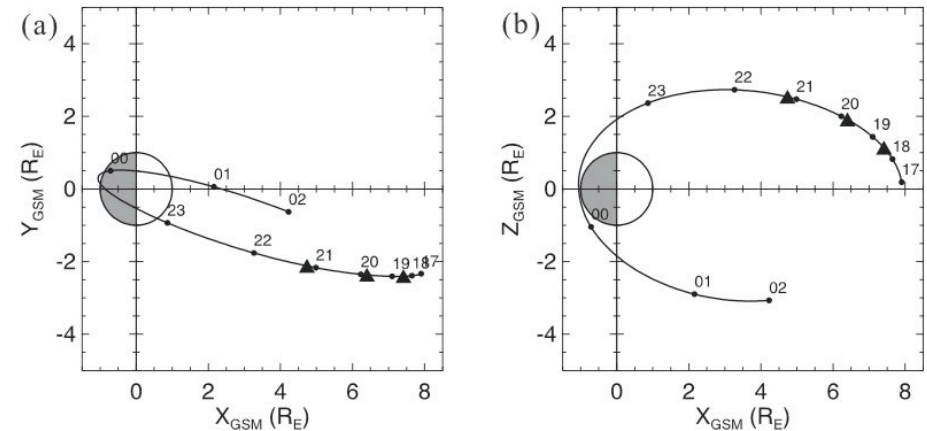
Nosé, Christon, Taguchi, Moore, Collier, JGR 2005, "Overwhelming O^+ ...
Yosemite 2006 T E Moore, NASA GSFC

Halloween Outflows TIDE and LENA

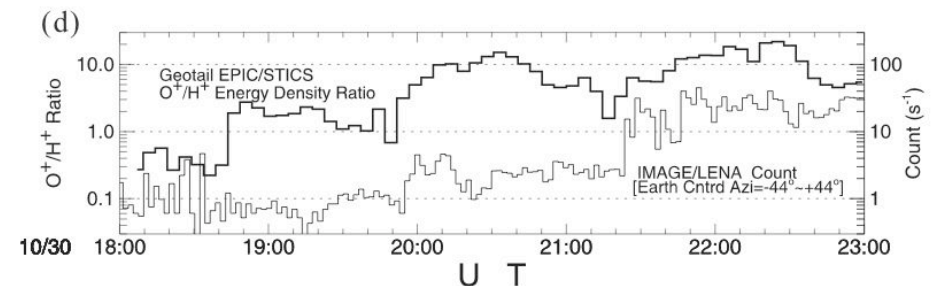
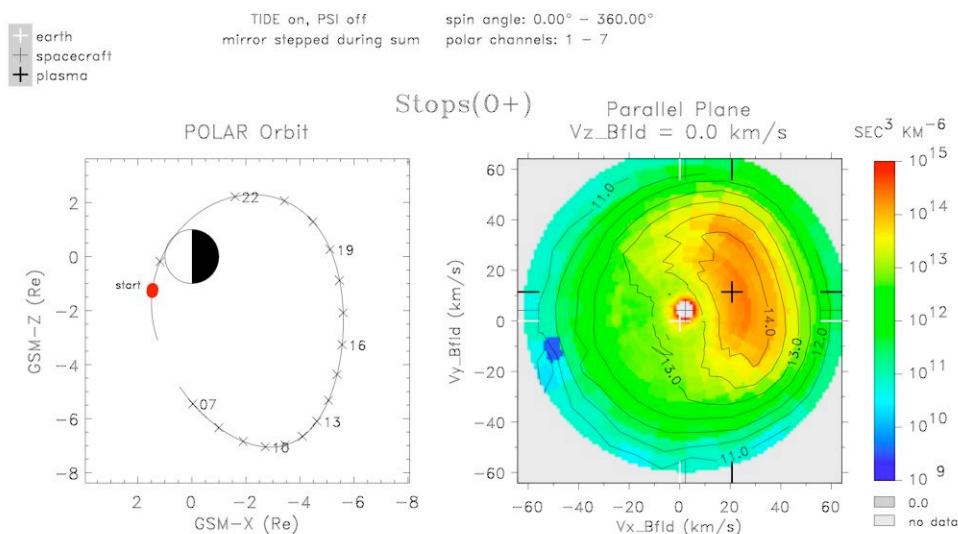
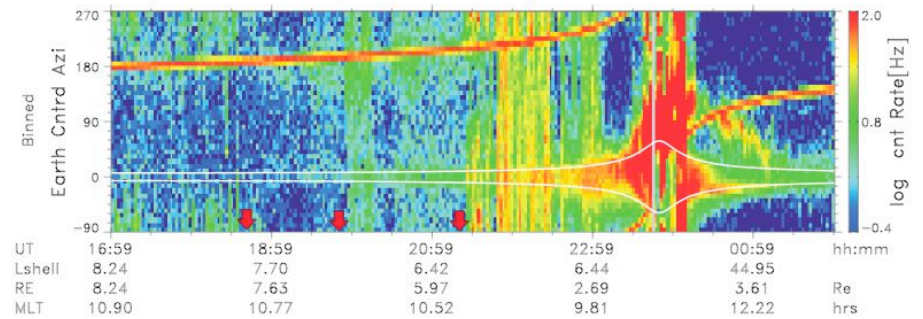


- Largest Polar/TIDE and IMAGE/LENA outflows ever observed
- Ion flux $\sim 1.5 \times 10^{10} \text{ cm}^{-2}\text{s}^{-1}$ is about 10 x flux for 24-25 Sep 1998

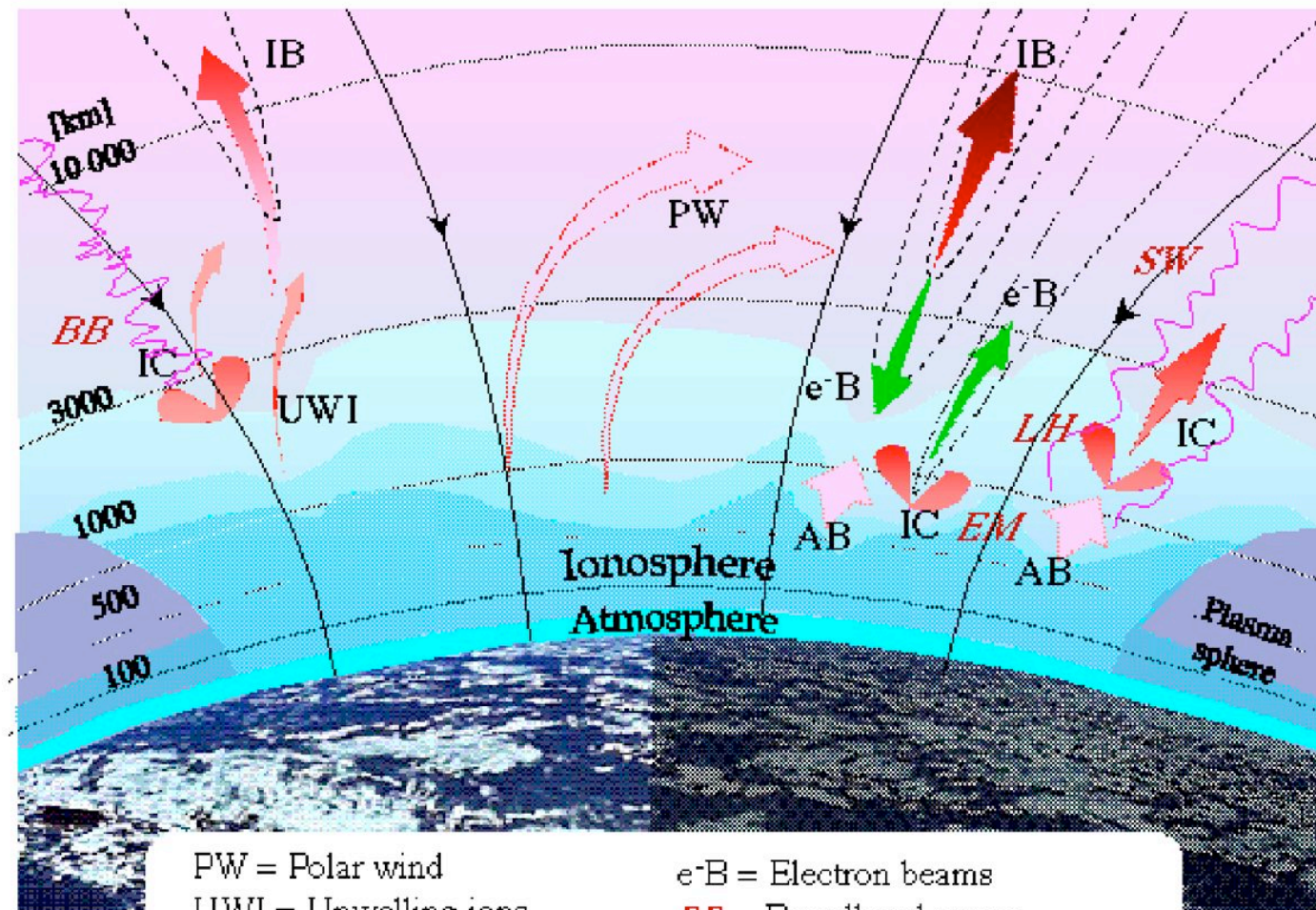
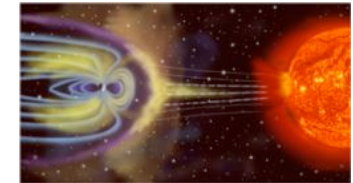
IMAGE Orbit 2003/10/30-31



(c) IMAGE/LENA Singles & Coincidences Binned
Start Time: 2003/10/30 (303) 17:00:00
Stop Time: 2003/10/31 (304) 02:00:00



Ionospheric Outflow Processes



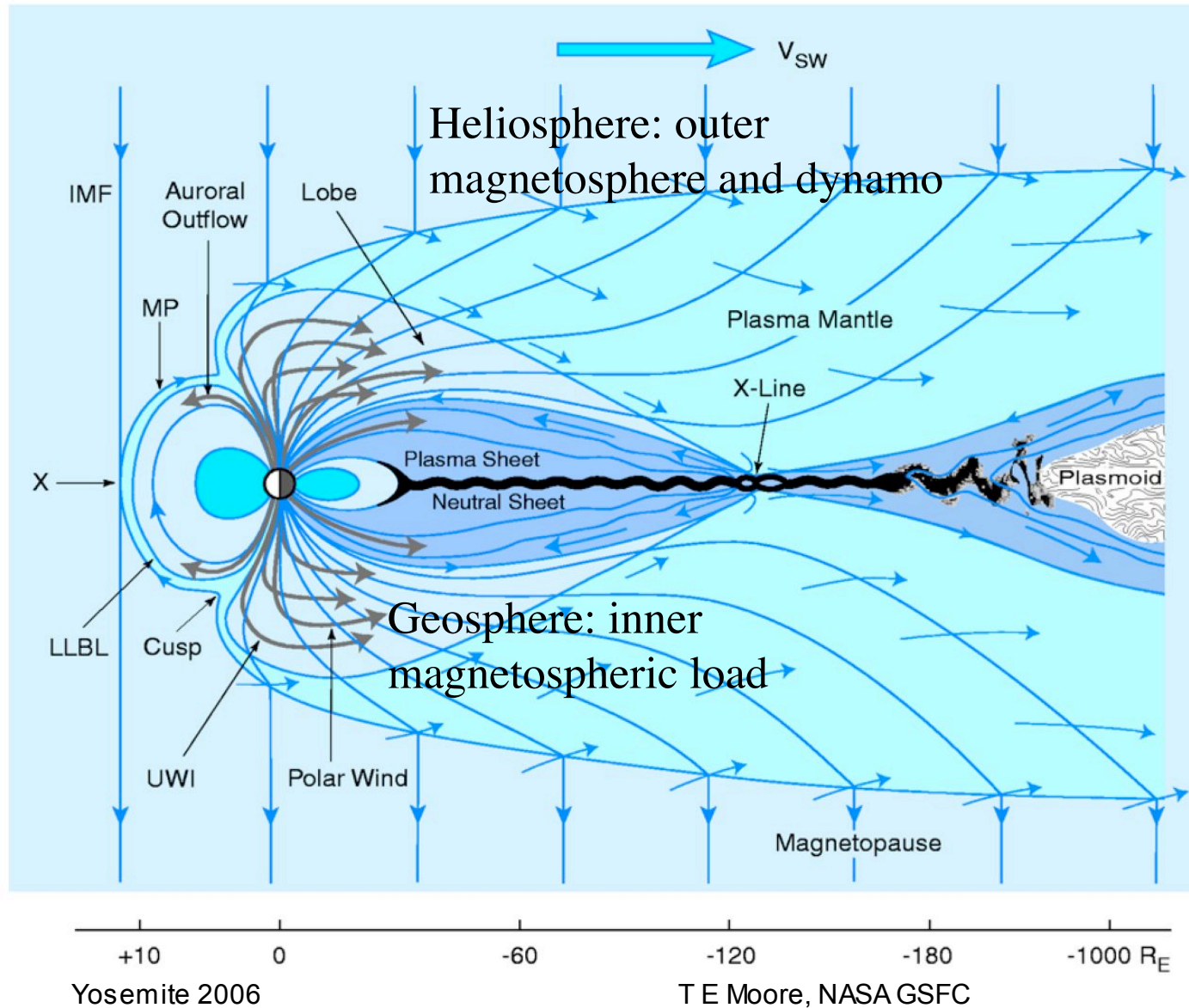
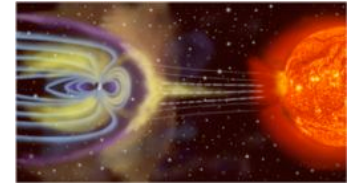
PW = Polar wind
 UWI = Upwelling ions
 IC = Ion conics
 IB = Ion beams
 AB = Auroral bulk upflow

e-B = Electron beams
 BB = Broadband waves
 LH = Lower hybrid waves
 EM = Ion cyclotron waves
 SW = Solitary Kin. Alfvén waves

1. Solar Wind
 photothermal
2. Polar Wind
 photothermal
3. Auroral Wind
 dissipative
 coupling of
 solar wind
 energy

After Moore, Lundin et al., SSR, 1999

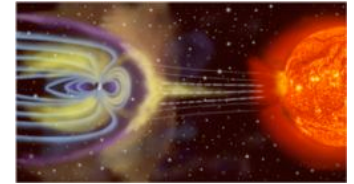
Ionospheric Global Circulation



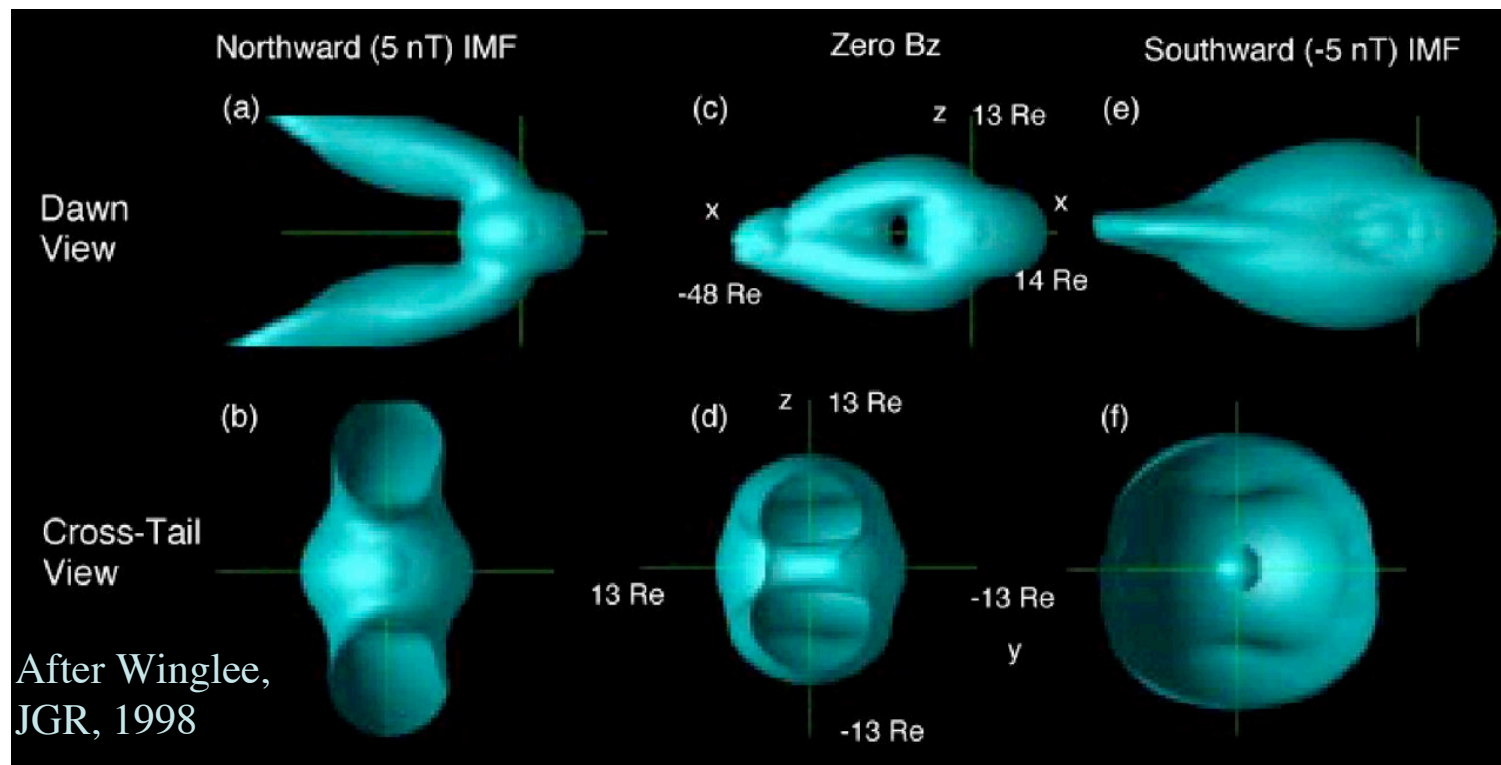
Magnetosphere:
electrodynamic
coupler of
dynamo to load
with feedback

After
Hultqvist, et
al. SSR, 1999

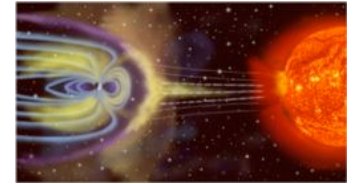
Heliosphere and Geosphere



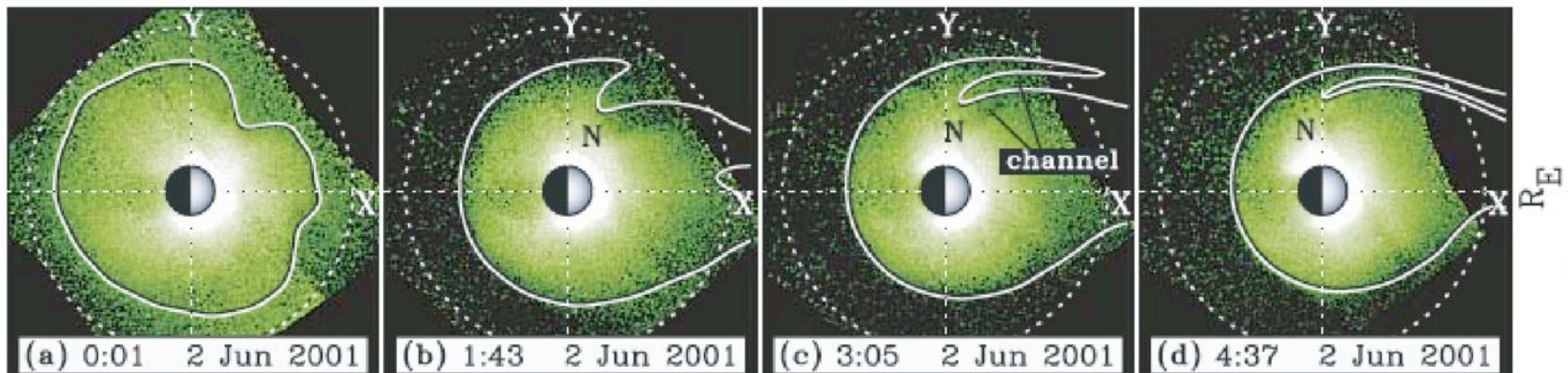
- Full 3D computations have taken us from cartoons into simulations.
- Initial efforts placed all ionospheric dissipation in the F layer, as a boundary condition to the simulations
- Recent innovations include ionospheric plasma fluids



Polar Wind and Plasmasphere

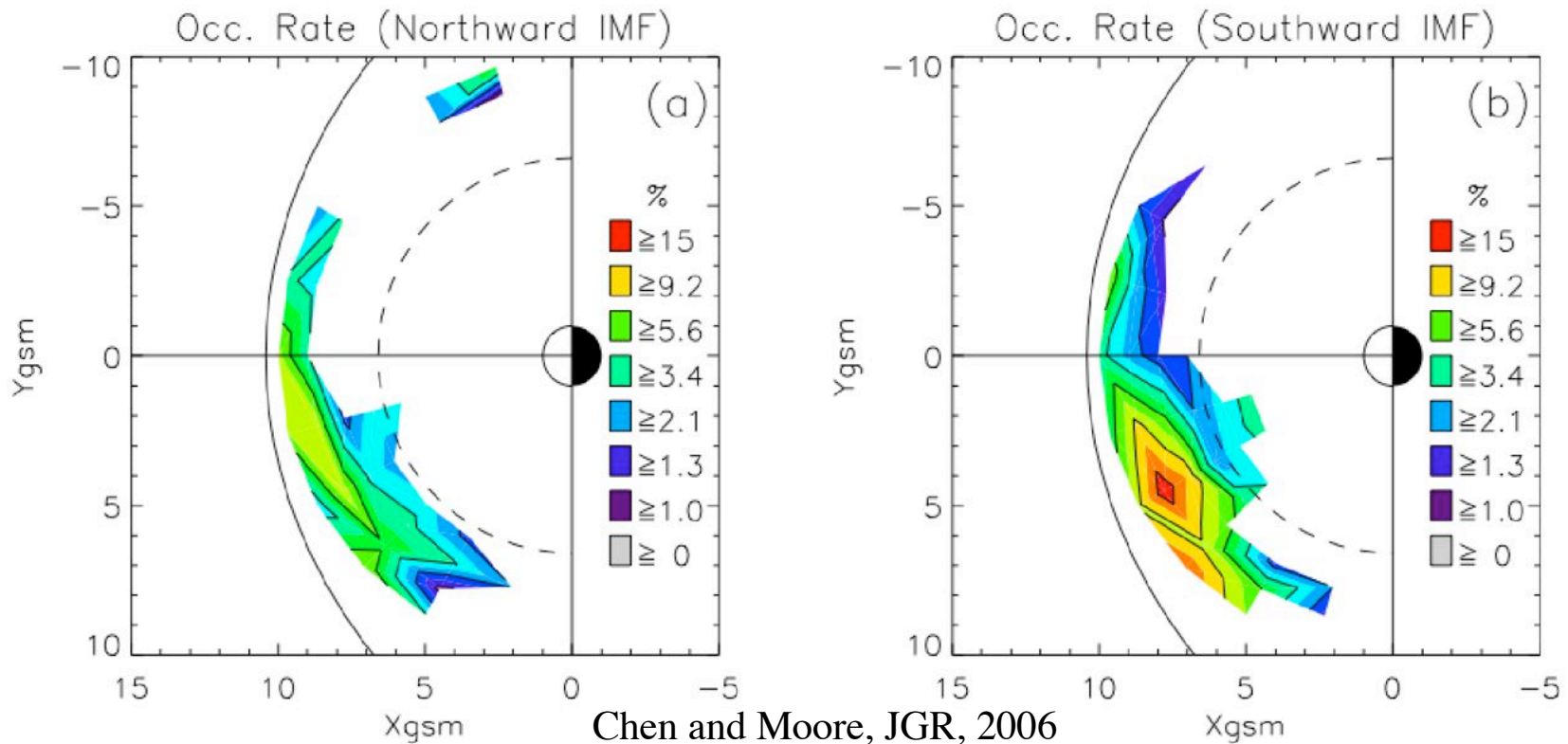
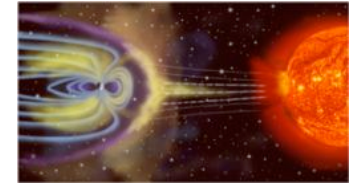


- Detailed dynamics of the extended light ion accumulation in the plasmasphere from the IMAGE mission.
- Basic features understood as effect of enhanced global sunward convection.
- Features such as spokes, ridges, sub-corotation point toward full simulations as dynamic element of the system



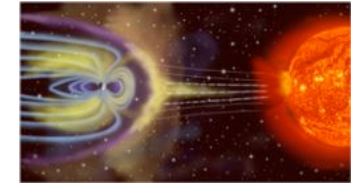
Goldstein, et al. JGR, 2002

Cold Plasma Plumes at M'pause



- Cold plasmas routinely present in the dayside magnetopause region, convecting according to IMF
- Densities increase to $\sim 50 \text{ cm}^{-3}$ during sunward flows
- Likely to load dayside reconnection via local depression of V_A

Quantifying Auroral Outflows



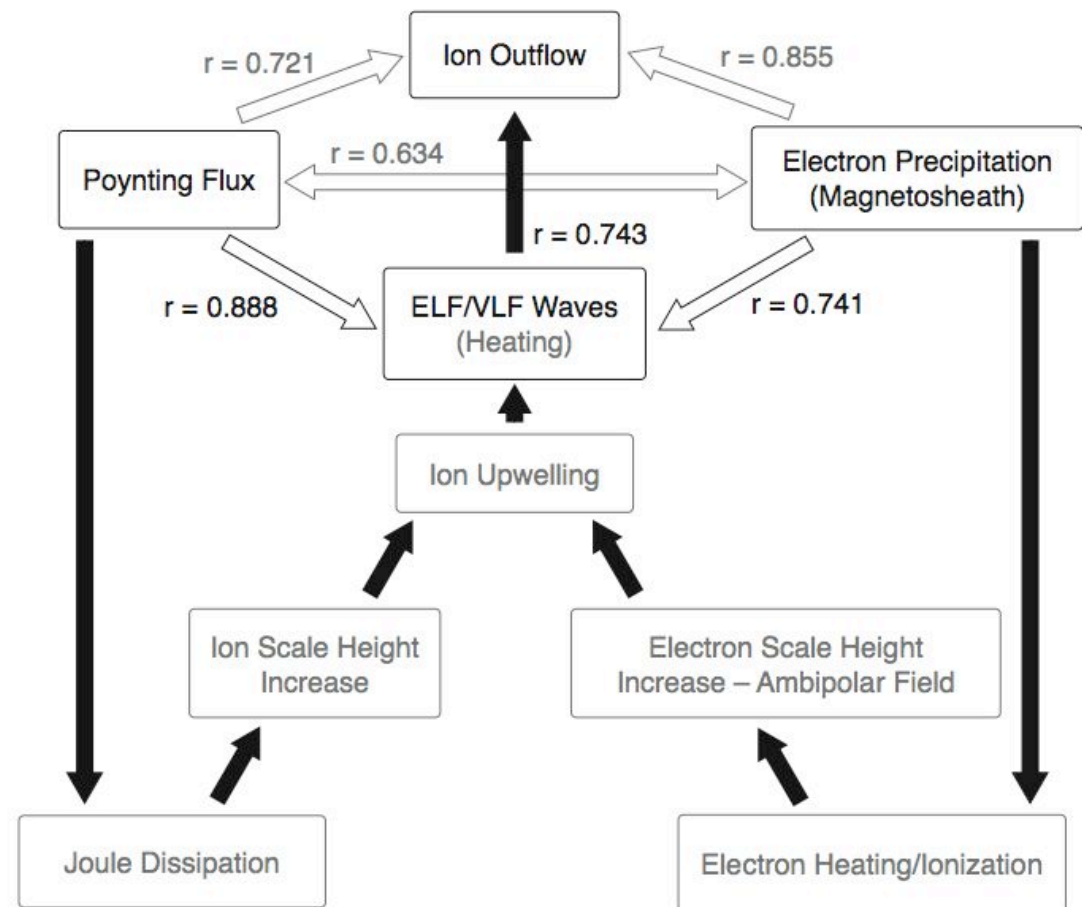
IMF and Pd relations
are inadequate to
specify full spatio-
temporal dynamics

FAST/Polar Empirical:

1. Ion heating:
 1. Friction (300 km)
 2. ICW (3000 km)
2. Electron heating:
 1. Soft e- (300 km)
 2. Hard e- (100 km)
3. “Centrifugal”
(pickup 10000+km)

Observed at FAST

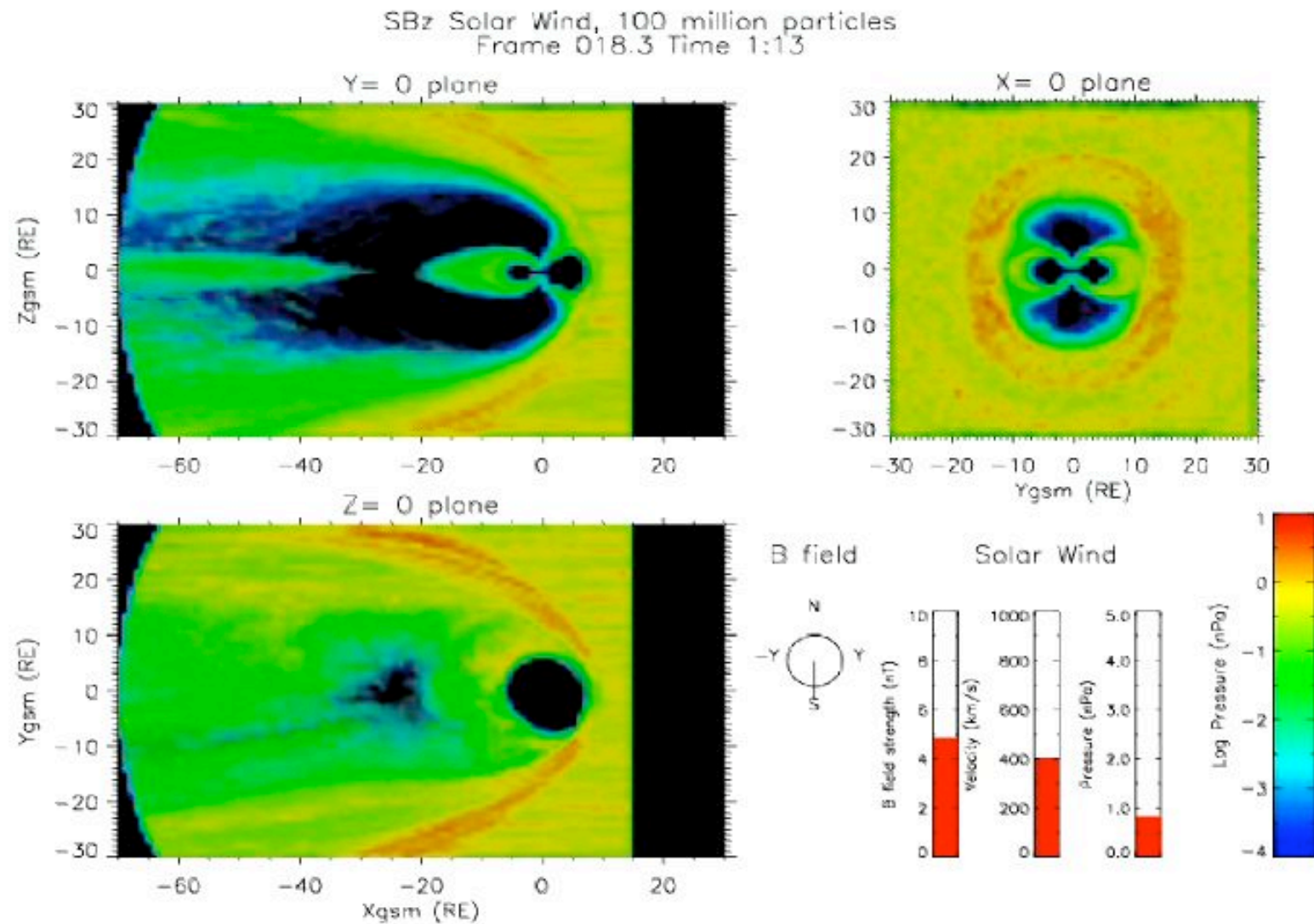
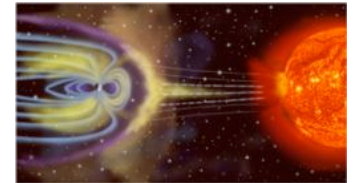
Inferred



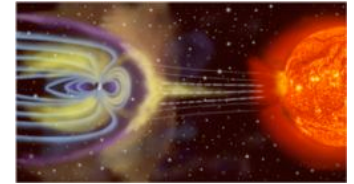
Strangeway et al., 2005; Zheng et al., 2005

→ Causal
 ⇨ Possibly Causal
 ⇨ Correlated

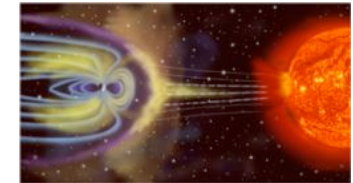
Dynamic Solar Wind: SBz Excursion



Dynamic Polar Wind: SBz Excursion



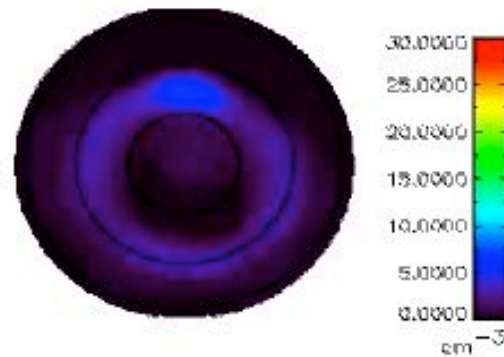
Dynamic Boundary Conditions: SBz Excursion



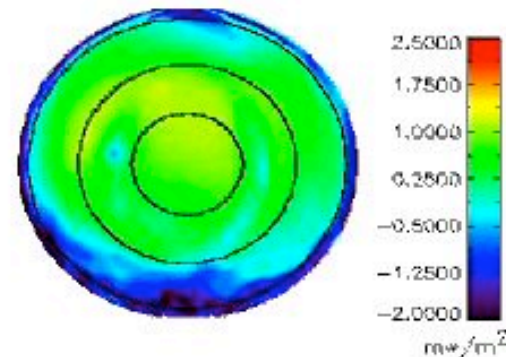
Ver 3

dSBz MHD Conditions

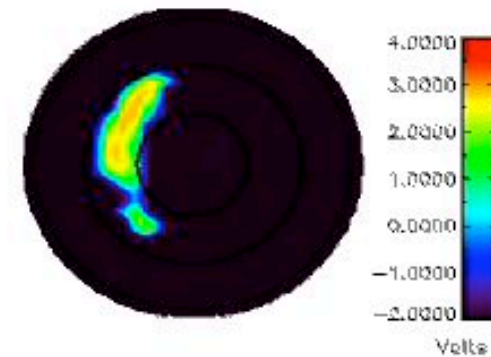
1:00.4 NCAPS.0720 Density



1:00.4 NCAPS.0720 Log Poynting Flux

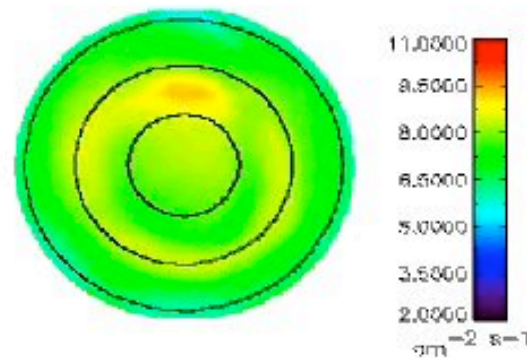


1:00.4 NCAPS.0720 Log Phi

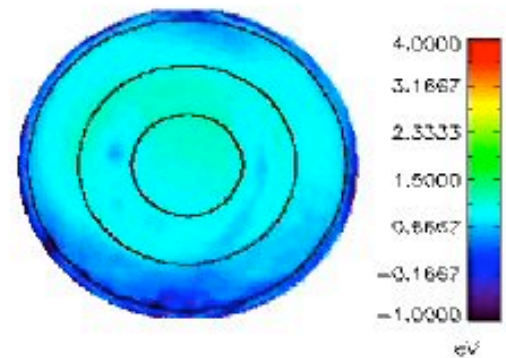


Auroral Wind Outflow Parameters

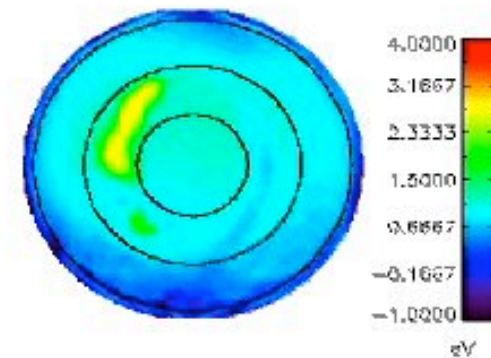
1:00.4 NCAPS.0720 Log Flux



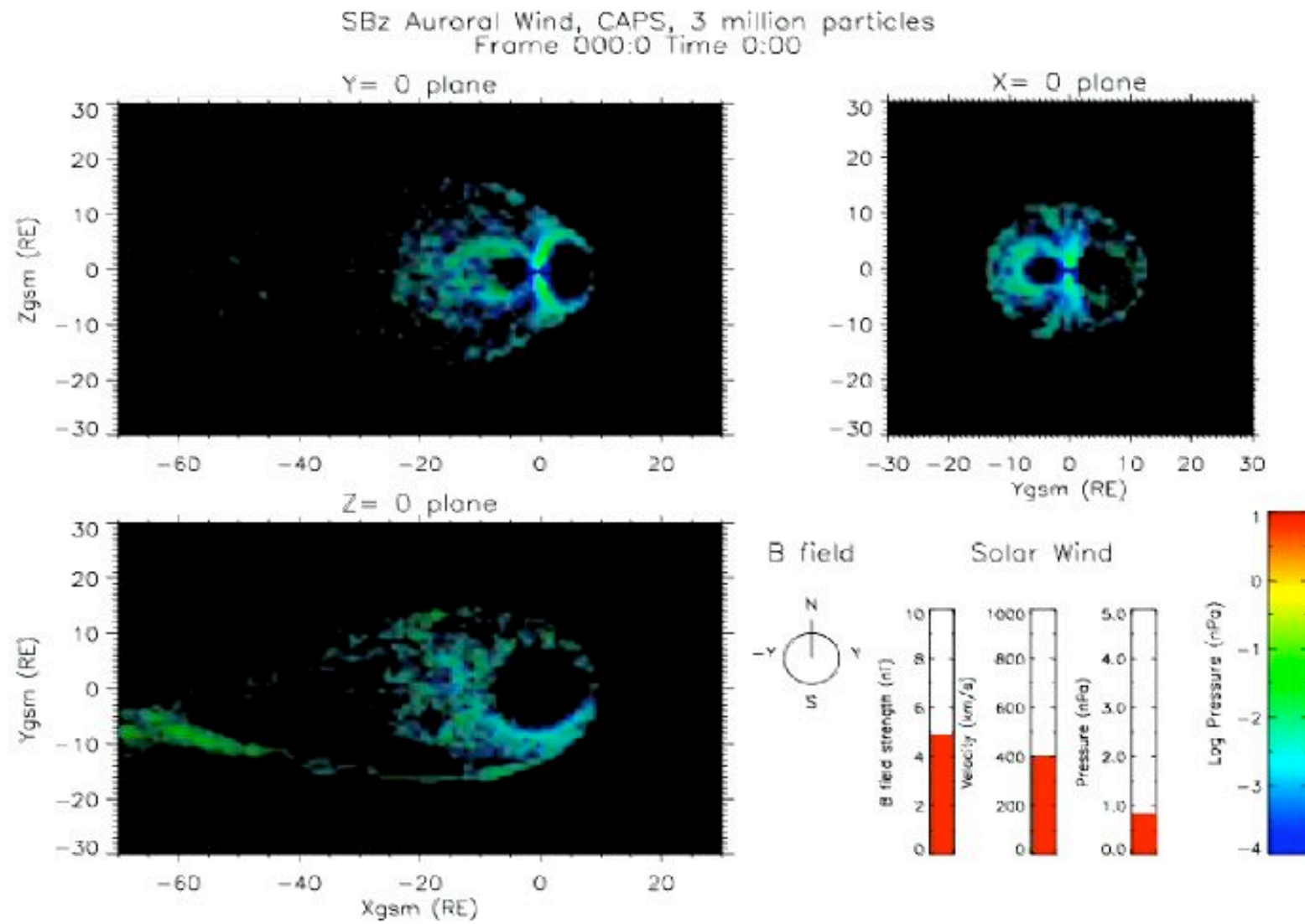
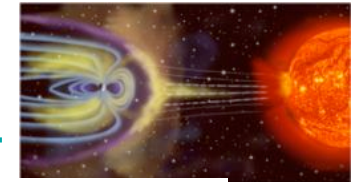
1:00.4 NCAPS.0720 Log Eth



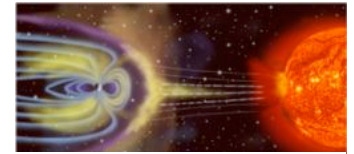
1:00.4 NCAPS.0720 Log E Parallel



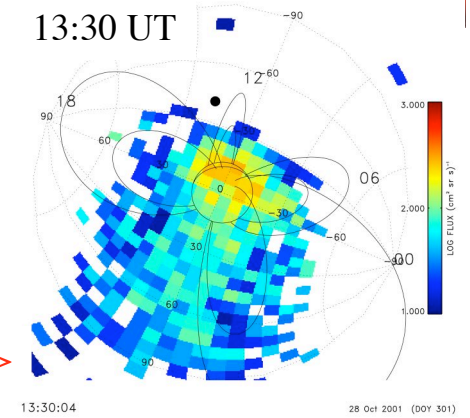
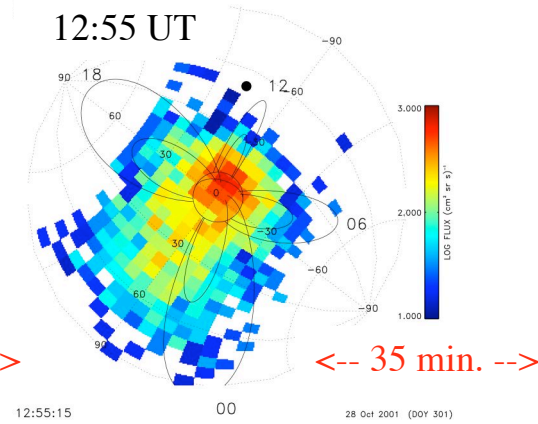
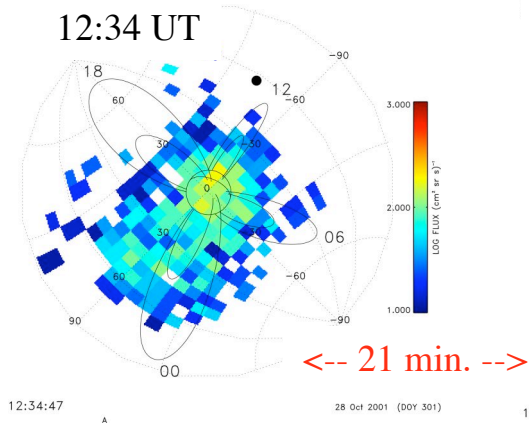
Dynamic Auroral Wind: SBz Excursion



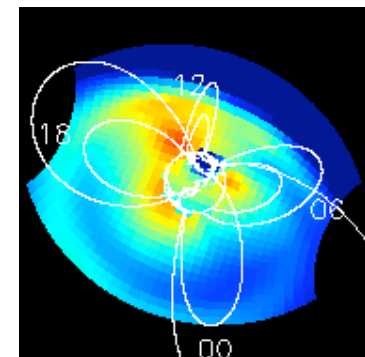
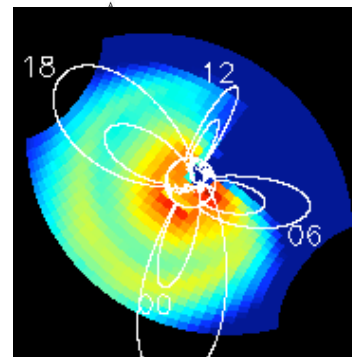
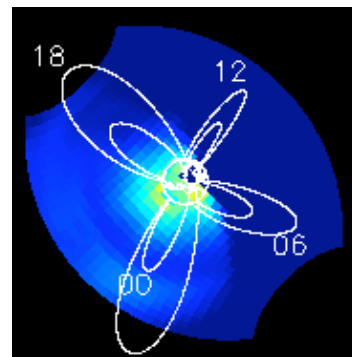
Substorm O+ ENA: Data - Model



HENA O
50-180 keV
28 October 01



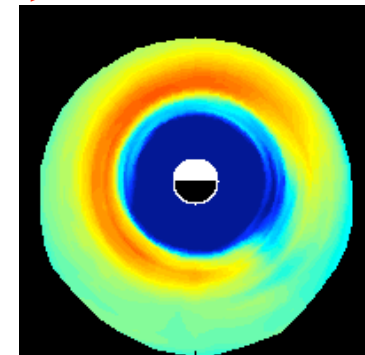
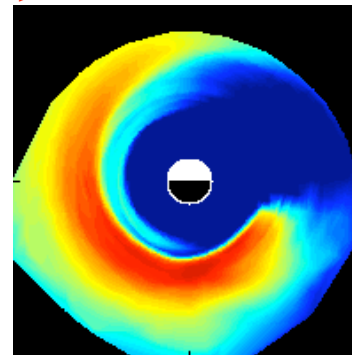
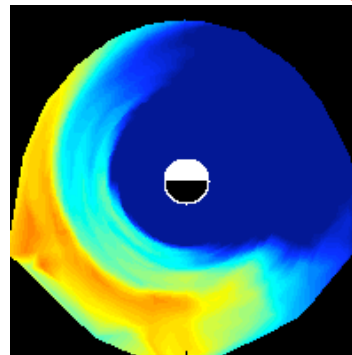
Simulated
O ENA



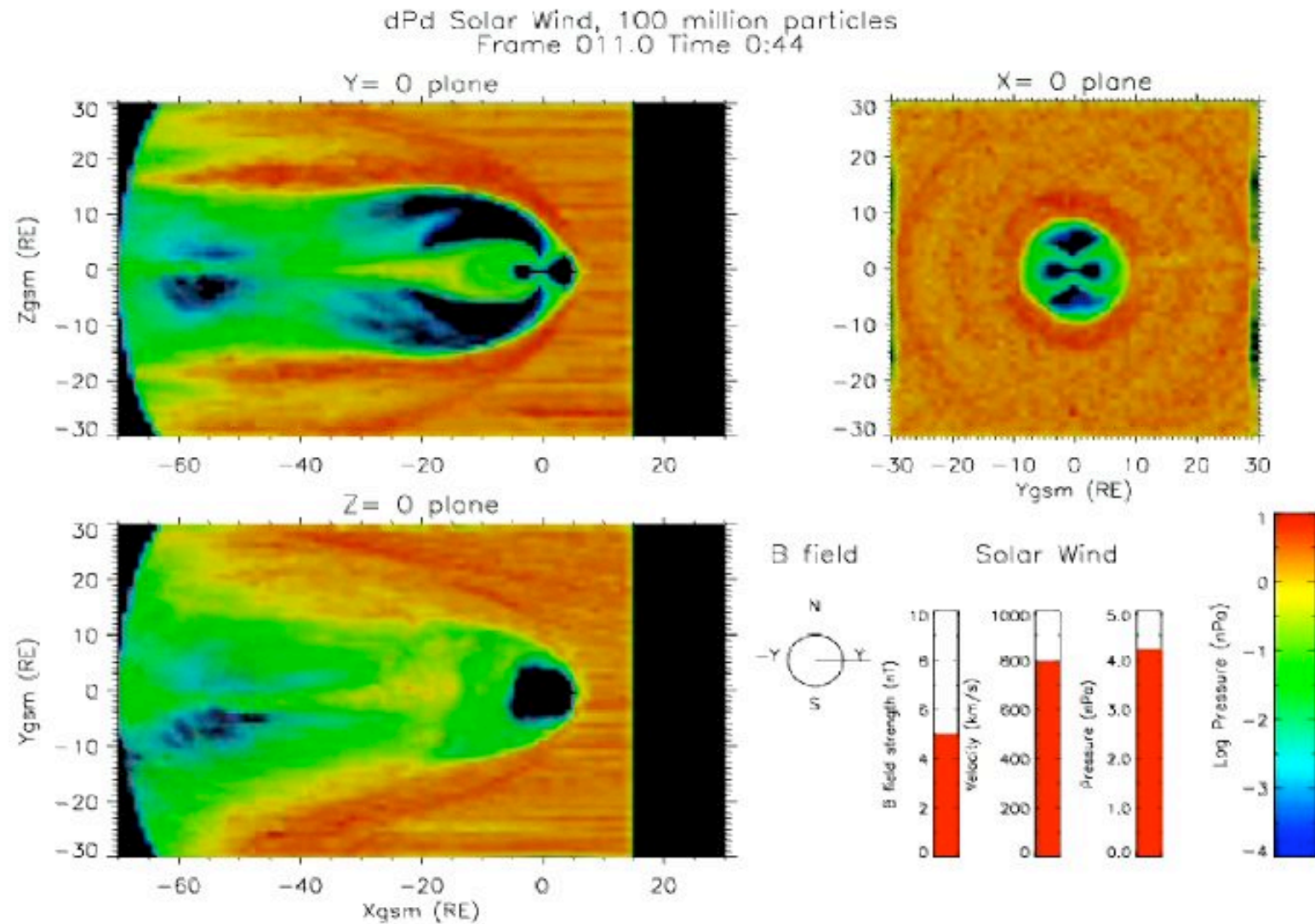
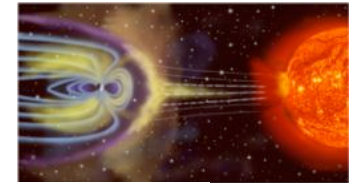
<-- 52 min. -->

<-- 60 min. -->

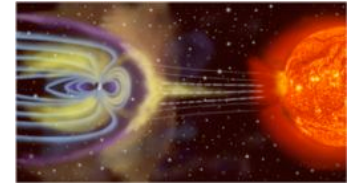
Simulated
O+



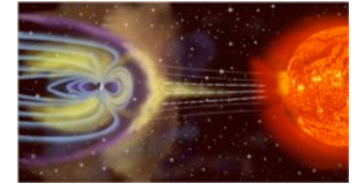
Dynamic Solar Wind: Pd Increase



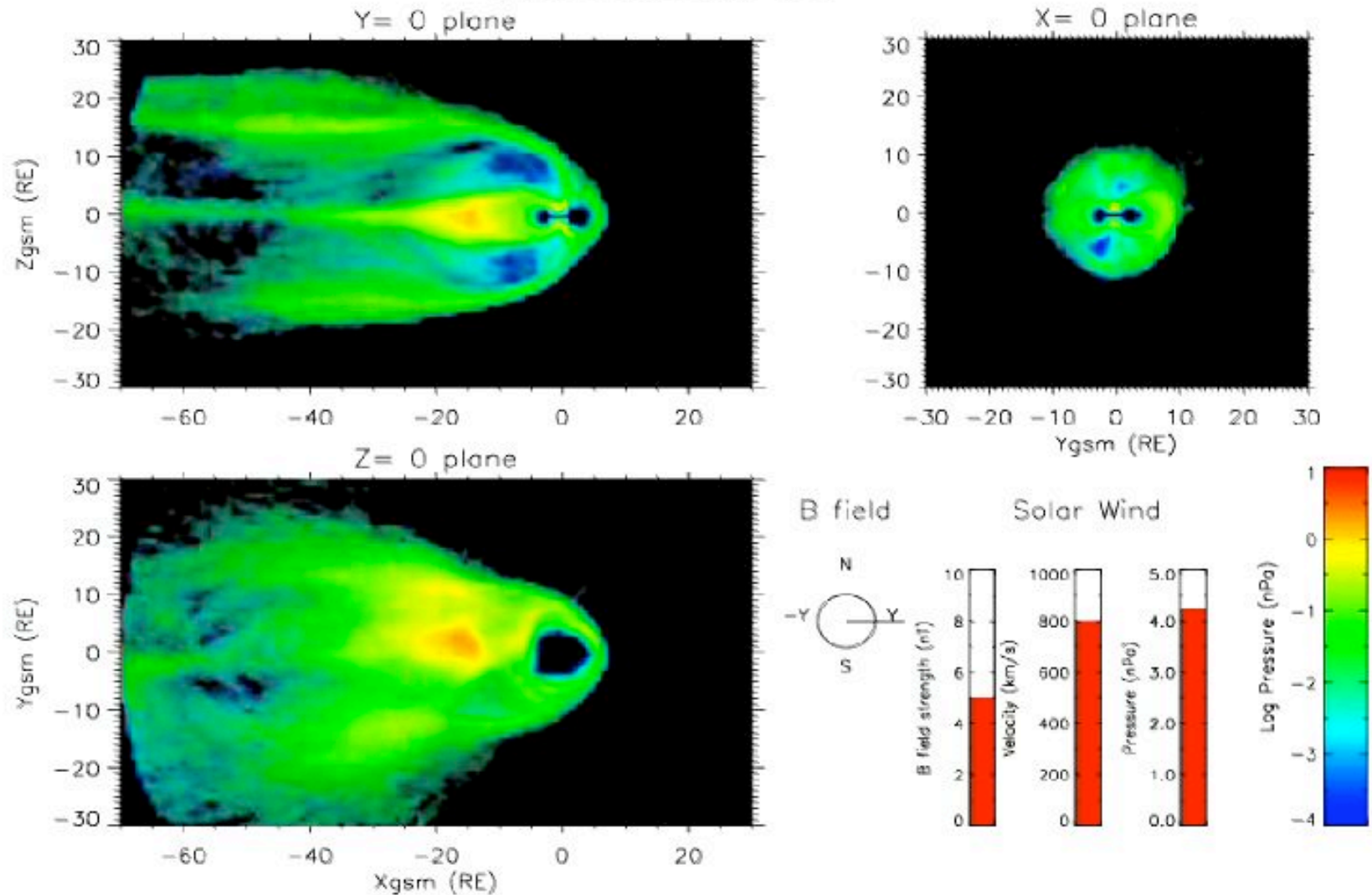
Dynamic Polar Wind: Pd Increase



Dynamic Auroral Wind: Pd Increase

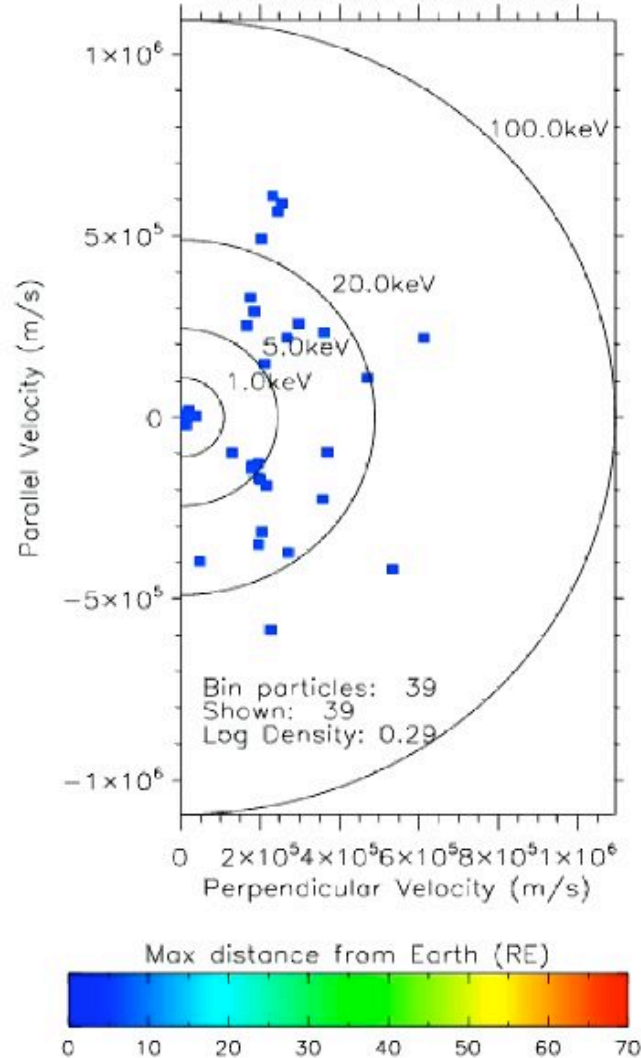


dPd Auroral Wind, CAPS, 3 million particles
Frame 011.0 Time 0:44

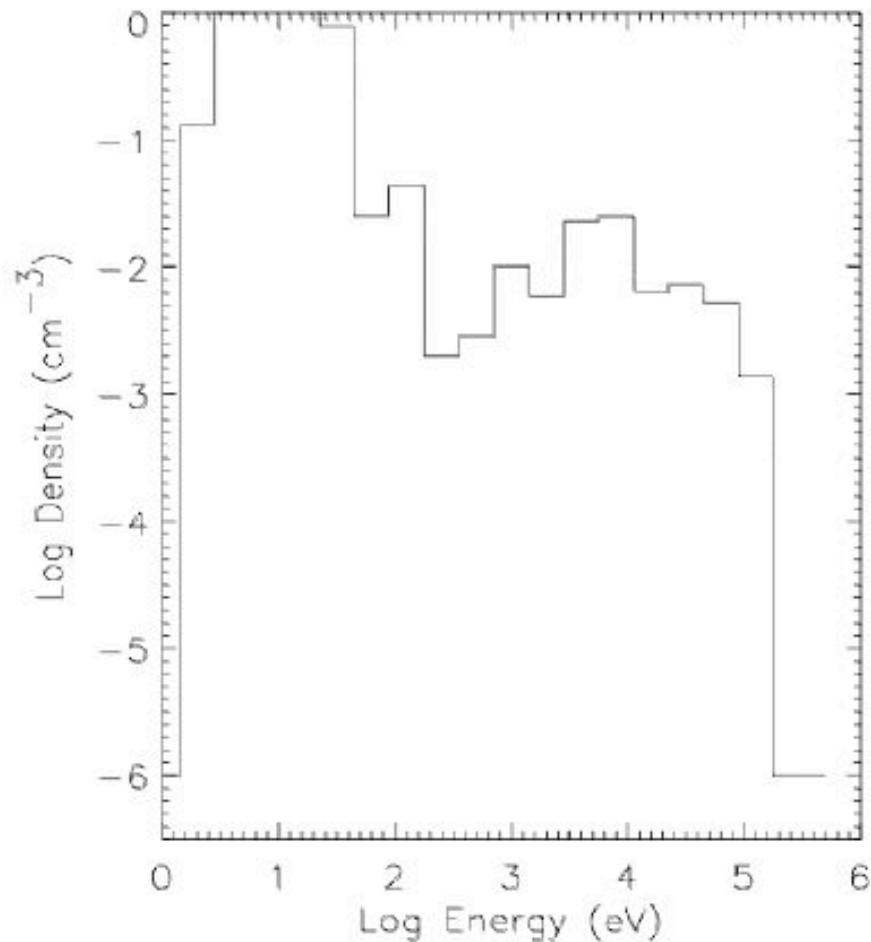


Virtual Spacecraft Dusk Geosync Region

dPd Auroral Wind, CAPS, 3 million part
X=0 RE Y=6 RE Z=0 RE
Frame 000 Time 0:00



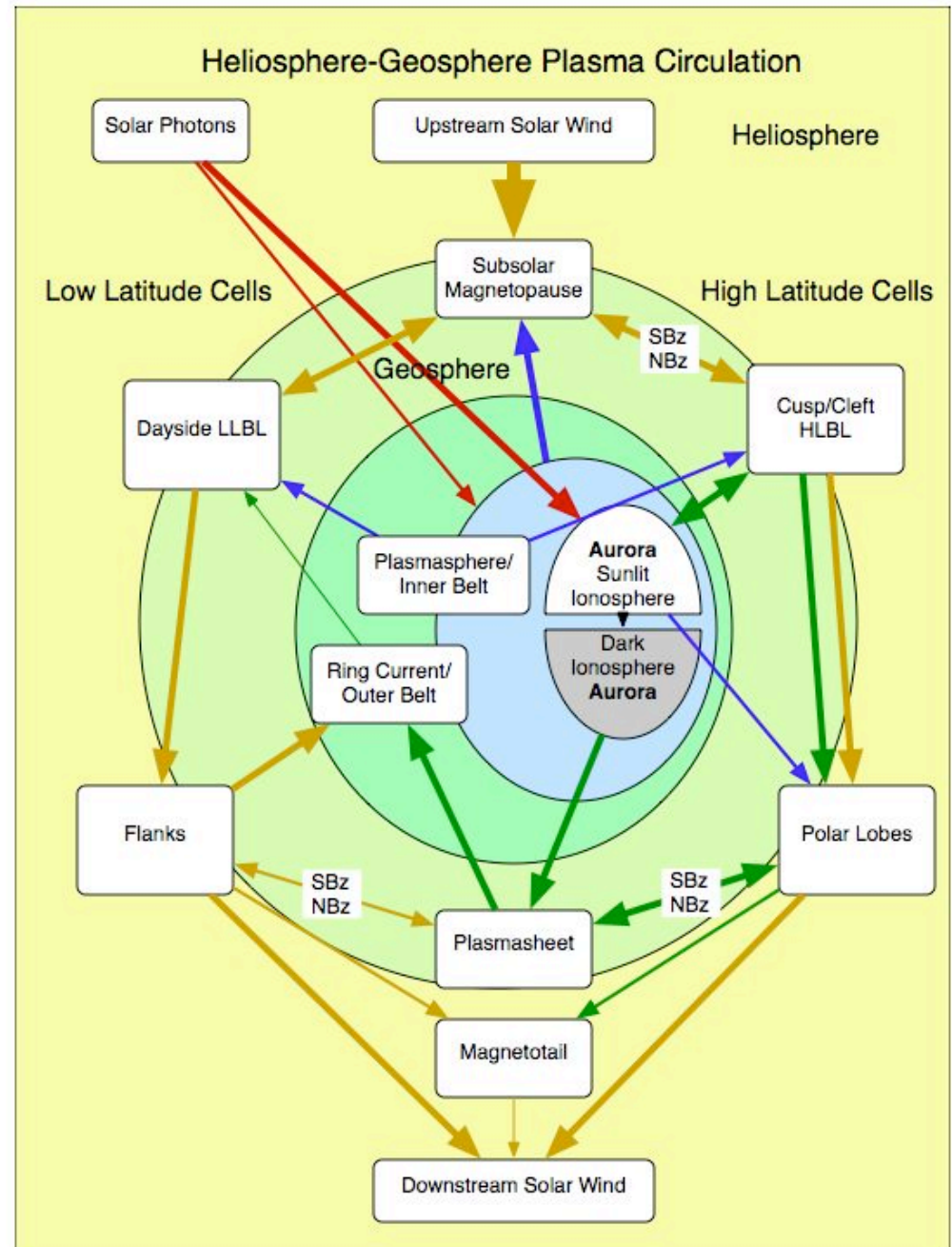
dPd Auroral Wind, CAPS, 3 million particles
X=0 RE Y=6 RE Z=0 RE
Frame 015 Time 1:00



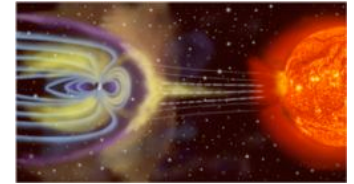
Integrated over pitch angle

H-G Circulation

- A plasma flow chart of the magnetosphere



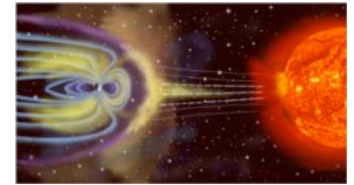
CONCLUSIONS



- Largest geospace storms supported by ionospheric ablation
- Driving auroral wind with local dynamic boundary conditions produces enhanced realism and detail
- Prolonged NBz *shuts down* the auroral wind.
- Substorms are triggered by both SBz, dPd
- Pre-existing auroral wind O⁺ outflows are highly compressed by solar wind pressure increase
- Auroral wind O⁺ increases with pressure increase, but delayed

Future Work

- Combined SBz and dPd in realistic storm sequences.
- Simulations with ionospheric plasmas as dynamical elements, e.g. Winglee code, others?
- Simulations with realistic inner magnetospheric fields, e.g. BatsRUS with CRCM, others?



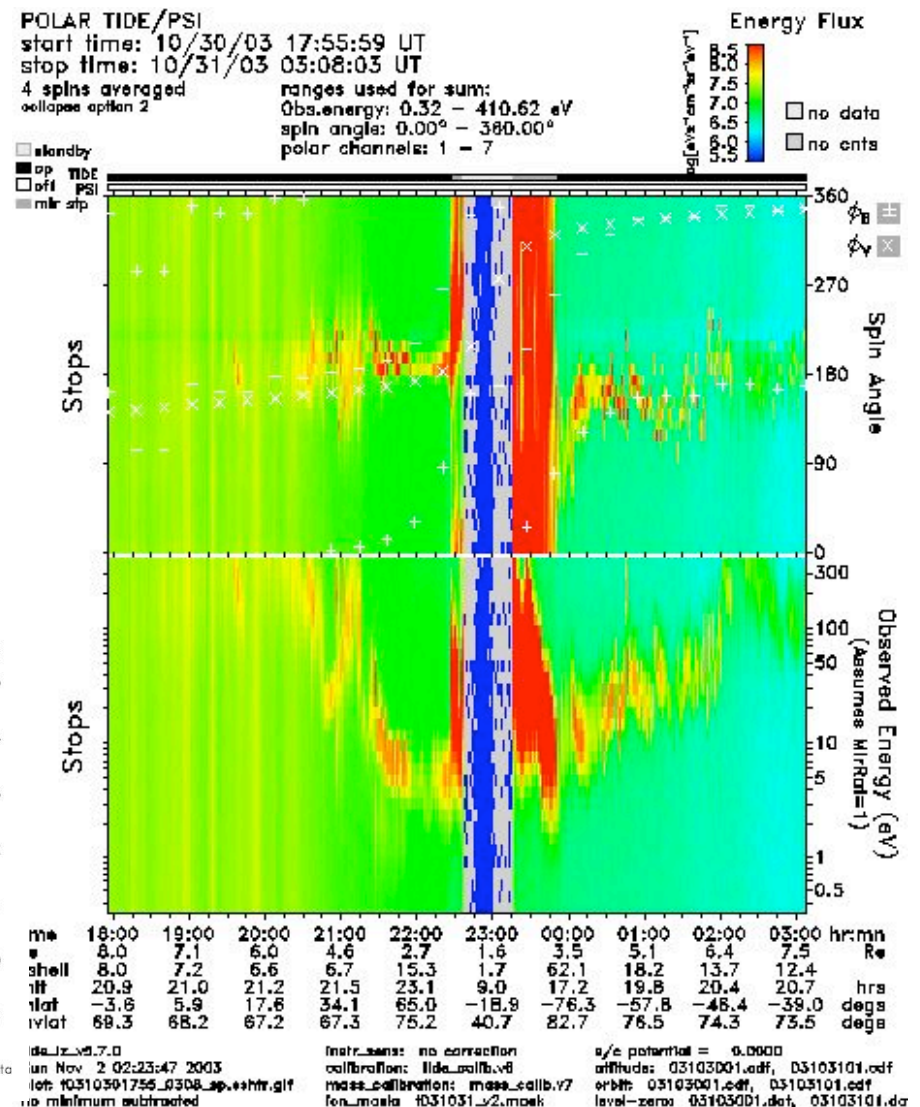
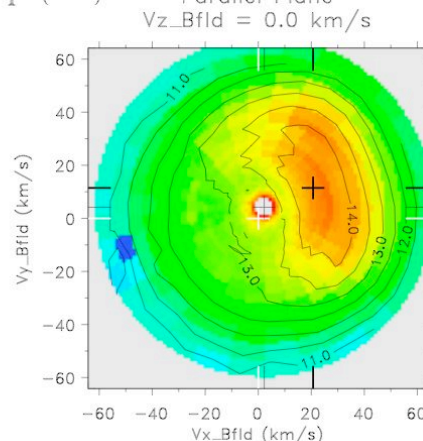
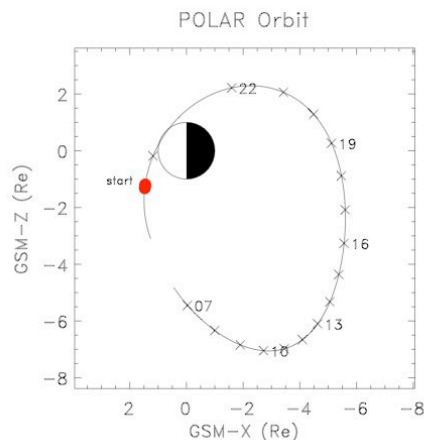
Backup/Discard Charts

A diagram illustrating the structure of a comet. On the left, the nucleus is shown as a small, dark, irregularly shaped body. Surrounding it is the coma, a large, diffuse, and glowing cloud of gas and dust. The coma is depicted with a yellowish-white core and a blue outer layer. To the right of the coma, the tail is shown as a long, narrow, and curved structure, composed of gas and dust, extending away from the nucleus. The background is a dark space filled with numerous small white dots representing stars.

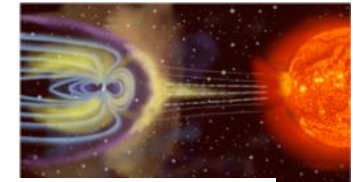
- + earth
- + spacecraft
- + plasma

Stops(0+)

Parallel Plane
 $V_z = Bfld = 0.0 \text{ km/s}$



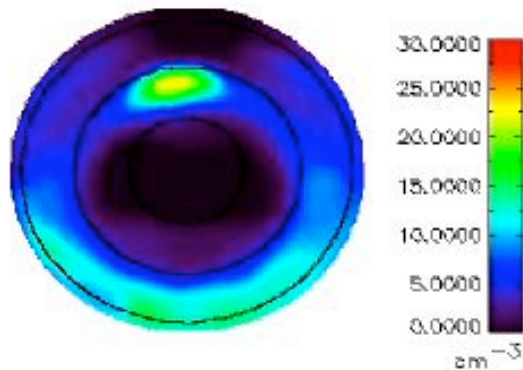
Dynamic Particle Boundary Conditions: Pd Increase



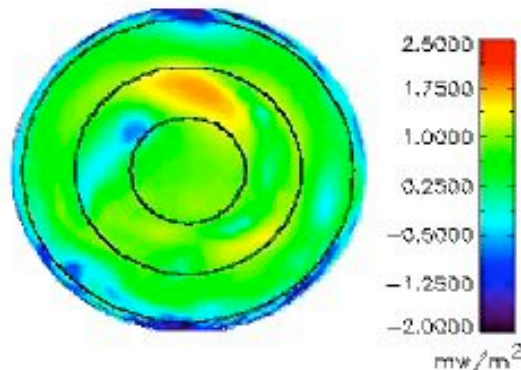
Ver 3

dPd MHD Conditions

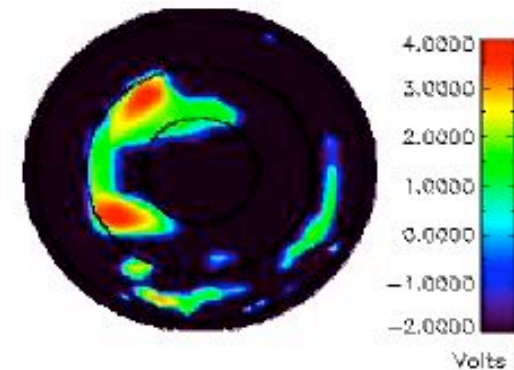
1:05.2 NCAPS.2430 Density



1:05.2 NCAPS.2430 Log Poynting Flux

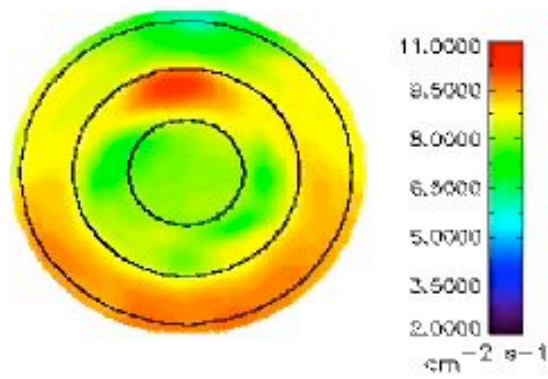


1:05.2 NCAPS.2430 Log Phi

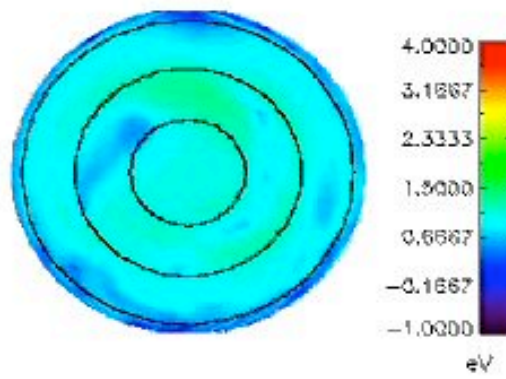


Auroral Wind Outflow Parameters

1:05.2 NCAPS.2430 Log Flux



1:05.2 NCAPS.2430 Log Eth



1:05.2 NCAPS.2430 Log E Parallel

